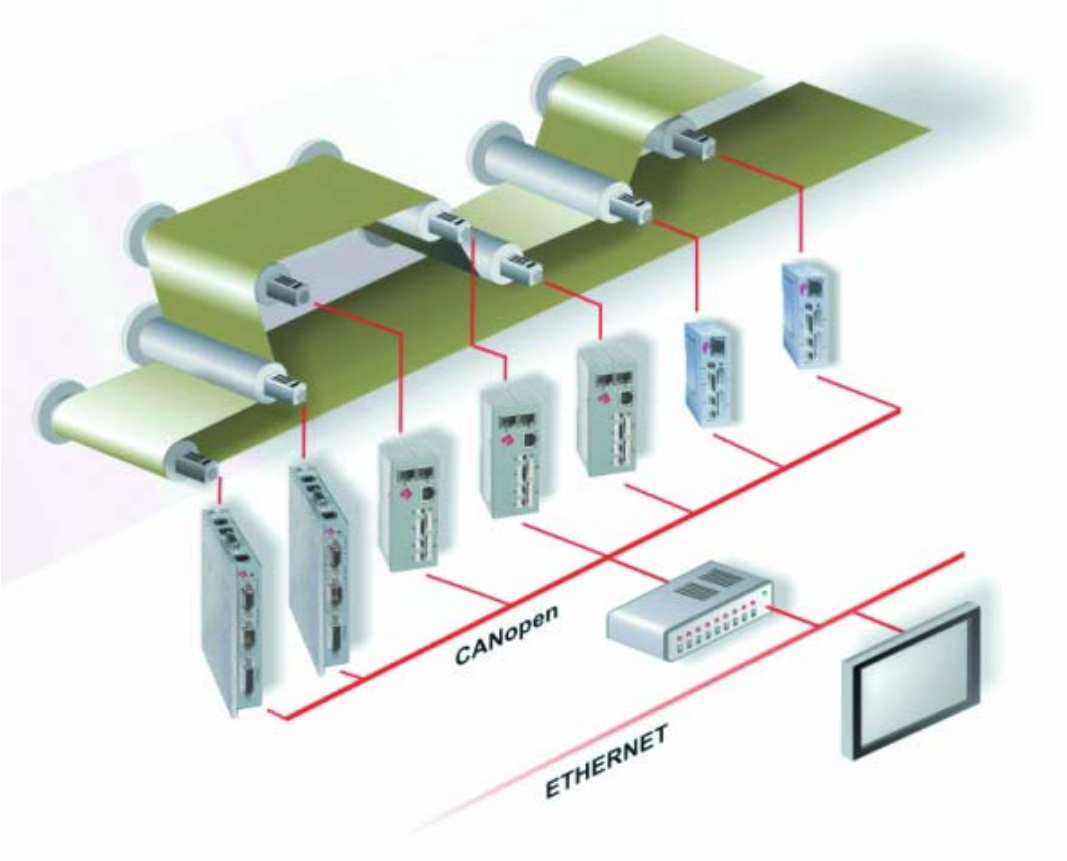
Elmo Motion Control
CANopen DSP 305
Implementation Guide



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Elmo
Motion Control

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- This guide contains proprietary information belonging to Elmo Motion Control Ltd. Such information is supplied solely for the purpose of assisting users of *SimplIQ* servo drives in implementing CANopen networking.
- The text and graphics included in this manual are for the purpose of illustration and reference only. The specifications on which they are based are subject to change without notice.
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Ver. 1.1 Apr. 2006 COB-ID Changes (MAN-CAN305IG)

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Contents

1 Introduction

This document describes the objects and operational modes of the Elmo DSP-based motion controller implementation of the CiA DSP 305 protocol. The Elmo Harmonica digital servo drive (part of the *SimplIQ* family of digital servo drives) is used whenever examples are shown in this document.

Notes:

- The *DSP* in CiA DSP 305 stands for *Draft Standard Proposal*.
- The *DSP* in Elmo DSP-based motion controller stands for *Digital Signal Processor*.

With the DSP 305 Layer Setting Services and protocol, unconfigured devices in a network can be identified by their unique manufacturer, product, serial and revision number. After identification Bit Rate and Node ID can be configured for each device.

1.1 Objectives of LSS

CiA DSP 305 CANopen *Layer Setting Service and Protocol (LSS)* services and protocols were created to enable the following parameters to be read and changed through the network:

- The CANopen Node ID
- The CAN baud rate
- The LSS address

This increases the "plug–and-play" capabilities of devices on CANopen networks as pre-configuration of the network is less restrictive.

The LSS Master is responsible for configuring these parameters on one or more LSS Slaves on a CANopen network.

1.2 Abbreviations and Terms

The following terms are used in this document:

COB	(Communication Object): A unit of transportation in a CAN network. Data must be send across a CAN network inside a COB. A COB can contain at most 8 bytes of data.
COB-ID	Each COB is uniquely indentified in a CAN network by a number called the COB Identifier (COB-ID). The COB-ID determines the priority of the COB for the MAX sub-layer.
Elmo Composer	An Elmo software application used for controller setup, application downloading and monitoring.
Hexadecimal	Numbers marked with either "h" (such as 1000h) or "0x" (such as 0x1000) refer to a hexadecimal value. Objects and numbers may appear in either form in different CAN documents

LMT	(Layer Management): Functions to inquire and change the settings of certain parameters of the local layers on a CAL module.
LSS	(Layer Setting Services): Functions to inquire and change the settings of certain parameters of the local layers on a CANopen network. An *LSS Master* can change the following parameters of *LSS Slaves*: ▪ Node ID ▪ Timing parameters of the physical layer (Baud Rate) ▪ LSS address The LSS Slave can be configured for a CANopen network without using any hardware based devices such as DIP-switches.
LSS Master	The device that configures other modules via a CANopen Network. There may be only one LSS Master in a network.
LSS Slave	The device that is configured by the LSS Master via a CANopen Network is called the LSS Slave.
MAC	(Medium Access Control): One of the sub-layers of the Data Link Layer in the CAN Reference Model that controls who gets access to the medium to send a message.
NMT	(Network Management): One of the service elements of the application layer in the CAN Reference Model. The NMT serves to configure, initialize, and handle errors in a CAN network.

1.3 LSS Hardware Restrictions (LSS Address)

All LSS Slaves must support valid Object Dictionary entries for Identity object [1018h] which has 32 bits for each part of the LSS Address:

- Vendor-ID (numerical number)
- Product-Code (numerical number)
- Revision-Number (major an minor revision as numerical number)
- Serial-Number (numerical number)

A Product-Code, Revision-Number and a Serial-Number are assigned by the device supplier. The LSS address which must be absolutely unique. No other LSS slave may have the same LSS address.

1.4 LSS Operating Restrictions

To function properly the following restrictions apply:

- All devices on a CANopen network must support LSS.
- There can be only one LSS Master.
- All nodes are required to start-up with the same initial baud rate.
- LSS communication can take place during any NMT state such as “stopped” or "pre-operational".

1.5 Elmo Documentation

This manual – included in the Elmo *CANopen Implementation Guide* – is part of the Elmo *SimplIQ* digital servo drive documentation set, as outlined in the following diagram:

In addition to this document, the *SimplIQ* documentation set includes:

- The Harmonica, Bassoon, Cello and Cornet *Installation Guides,* which provides full instructions for installing *SimplIQ* digital servo drives.
- The Composer *User Manual,* which includes explanations of all the software tools that are a part of Elmo's Composer software environment.
- The *SimplIQ Software Manual,* which describes the comprehensive software used with the *SimplIQ* line of digital servo drives.
- The *CANopen Implementation Guide,* which explains how to implement CANopen DS 301-based communication (including DSP 402) with a *SimplIQ* digital servo drive.

Note:
SimplIQ drives are fully compliant with CiA's DSP305 protocol for Layer Setting Service (LSS).

2 LSS Modes

Devices that communicate with the LSS protocol can be in one of two modes, '*Configuration Mode*' and '*Operation Mode*'. Any device on the network that is not in 'Configuration Mode' is in 'Operation Mode'. In 'Configuration Mode' all LSS services are available. In 'Operation Mode' only the switch mode services are available.

Switching the mode of a device to 'Configuration Mode' must be explicitly initiated by the LSS Master. Mode switching is independent of the NMT state. With the exception of the LSS service 'Configure Node-ID' the NMT state of the device is not affected by LSS services.

If the Node-ID of the LSS Slave is changed with the LSS service 'Configure Node-ID', and the slave is switched back from 'Configuration Mode' to 'Operation Mode', a power-on like reset must be performed by the LSS slave; this affects the NMT state. For this reason the LSS-Master must reside on the same device that holds the NMT-Master.

2.1 Configuration and the Operation Modes

An LSS Slave can be in one of two LSS modes:

Configuration Mode

- When an LSS Slave is in this mode, it actively listens for and processes configuration commands from the LSS Master.
- Some configuration commands configure only one LSS Slave at the time (for example, to change of CANopen node ID)
- Some configuration commands configure multiple or all LSS Slave nodes (for example, to change the baud rate)

Operation Mode

- An LSS Slave in this mode ignores the configuration commands from the LSS Master.

3 LSS Services

LSS services can be functionally grouped into four categories:

- **Switch Mode Services** provide a way to logically connect the LSS Master and LSS Slave(s) for configuration purposes. They change the LSS mode attribute of the LSS Slave (see the **Figure 3-1**).
- **Configuration Services** perform the actual task of configuring the layer parameters of LSS Slave(s). The configuration services are only available in configuration mode.
- **Inquiry Services** provide a way for the LSS Master to determine layer parameters. The inquiry services are available only in configuration mode.
- **Identification Services** provide a way for the LSS Master to determine the presence of a device and to check for devices with invalid Node-ID. The identification services are available in configuration and operation mode.

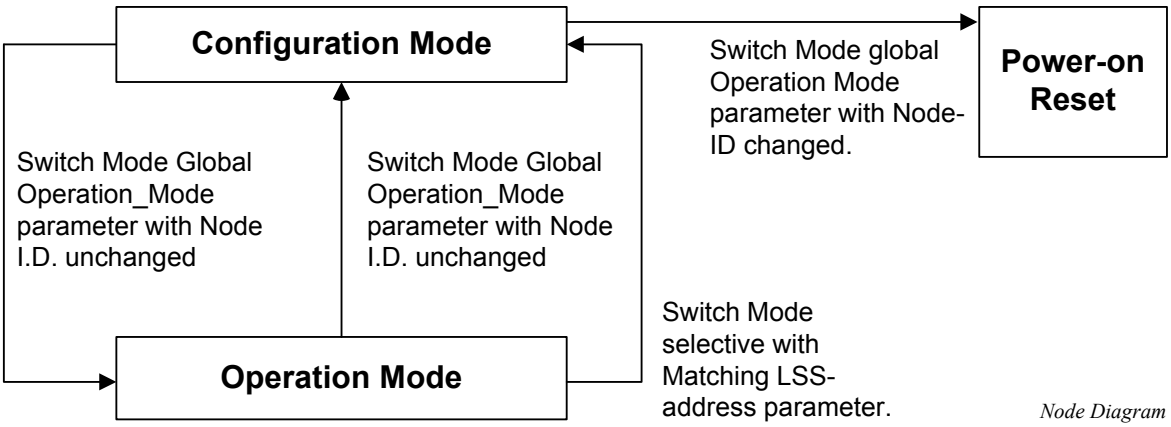


Figure 3-1 LSS Slave Modes and Switching Services

3.1 LSS Master-Slave Synchronization & Protocol

In the LSS Protocol all slaves use the same Communications Object (COB) to send information to the LSS Master. In order to ensure that only one LSS Slave communicates with the LSS Master at a time, a switching mechanism, under the control of the LSS Master is implemented.

A slave can only communicate with the Master after it has been switched into Configuration Mode by the master. In other words, the Master must first take the initiative. Furthermore, the Slave only communicates specific information requested by the Master.

The protocols described below all have the same structure: a specific sequence of COBs are exchanged between the LSS Master and LSS Slave for a particular LSS service. Requesting Messages use COB-ID 7E5h while Response Messages use COB-ID 7E4h.

LSS uses Command Specifiers (CS) to identify the commands. CSs from 00 - 03fh are reserved for use by the LMT. 040h - 07fh are reserved for use by standard LSS services. Command Specifiers 080h – 0ffh are free for application specific purposes, but may only be used with one Slave in Configuration Mode at a time.

In the COB data format bytes are numbered from 0 to 7. Bits within a byte are also numbered from 0 to 7 with bit 0 being the least significant bit (LSB), and 7 the most significant (MSB).

3.2 Switch Mode Services

Switch Mode Services controls the mode of LSS Slaves. There are two ways to put an LSS Slave into configuration mode, with *Switch Mode Global* and with *Switch Mode Selective*. *Switch Mode Selective* switches one LSS Slave between configuration and operation mode. *Switch Mode Global* switches all LSS Slaves between configuration and operation mode.

If the Node-ID of a slave is changed with the LSS 'Configure Node-ID' service, a Switch Mode Global with the operation_mode parameter causes a power-on-like reset of the LSS Slave to force a change in the slave's default set-up parameters.

3.2.1 Switch Mode Global

This service is used to switch all LSS Slaves in the network between operation mode and configuration mode.

COB-ID = 7E5h

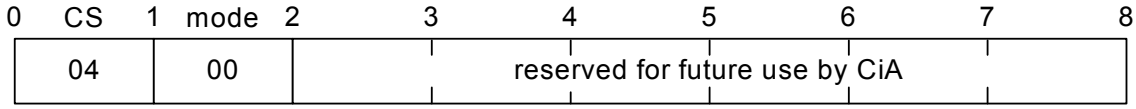


Figure 3-2 Switch all Slaves to *Operation Mode*

COB-ID = 7E5h

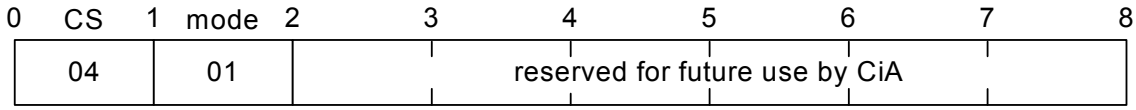


Figure 3-3 Switch all Slaves to *Configuration Mode*

3.2.2 Switch Mode Selective

This service is used to switch a specific LSS Slave device to configuration mode.

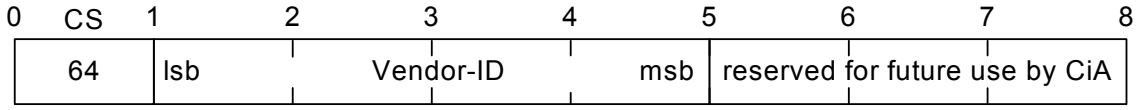


Figure 3-4 Switch Slaves, from Specific *Vendor,* to Configuration Mode

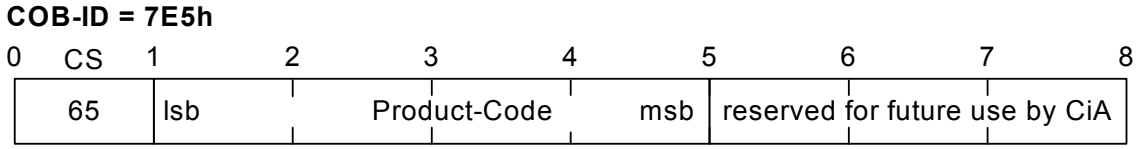


Figure 3-5 Switch Slave, with Specific *Product-Code,* to Configuration Mode

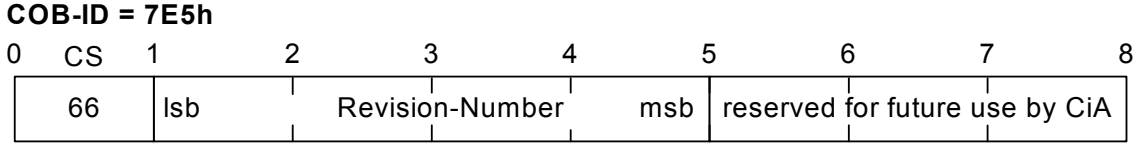


Figure 3-6 Switch Slaves, with Specific *Revision-Number,* to Configuration Mode

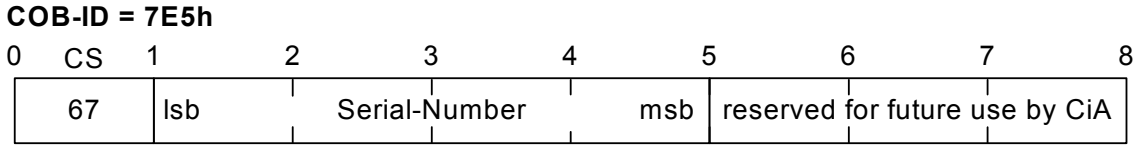


Figure 3-7 Switch Slaves, with Specific *Serial Number* to Configuration Mode

To switch to a specific device, all four of the above commands must be sent.

3.3 Configuration Services

Configuration services are available only in configuration mode. Some of the services are only available to one LSS Slave device.

3.3.1 Configuration Node-ID

This service enables the LSS Master to configure the NMT-address of an LSS Slave. Only one LSS Slave at a time can be configured with this service. A remote result message confirms the success or failure of the service.

This service works in Configuration Mode. A change in the Node-ID causes a power-on like reset to the device.

COB-ID = 7E5h

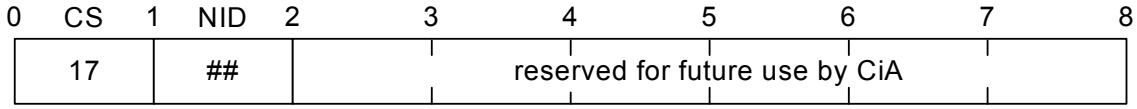


Figure 3-8 Switch the Node-ID of a Slave

NID (Node-ID):

If NID is set to FFh it becomes invalid when switching to operation mode. As a result, the slave enters the 'LSS Init State' autonomously.

COB-ID = 7E4h

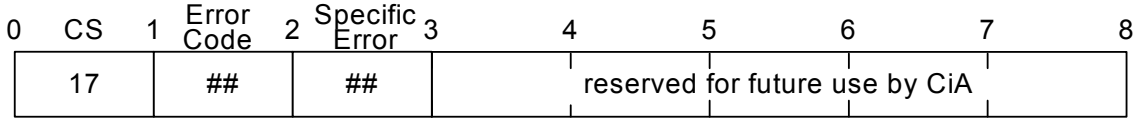


Figure 3-9 Confirm the Node-ID of a Slave

Error Codes:

0: protocol successfully completed
1: Node-ID out of range
2 ... 254: reserved for further use by CiA
255: implementation specific error occured.

Specific Error Codes:

If error_code is 0 … 254, then a specific_error_code will be 0.

If error_code is 255, then a specific_error_code will be:

2: incorrect mode
no other options at this time

3.3.2 Configuration Bit Timing Parameters

The LSS Master's Configure Bit Timing Parameters service sets new bit timing on an LSS Slave. The bit timing parameters for different baud rates are specified in the Bit Timing Parameter Table below. With table_selector value ´0´ the standard CiA bit timing parameter table is used. The table_index selects the entry (baud rate) in the selected table (value '0' refers to the highest baud rate).

Table Selector Table:

Table	Selection
0:	standard CiA Bit Timing Table
1…127:	reserved for further use by CiA
128…255:	for use by manufacturer for specific but timings

Note:
Elmo drives only work with the standards CiA Bit Timing Table.

Standard CiA Bit Timing Table:

Table Index	Baud Rate
0	1000 kBit
1	800 kBit
2	500 kBit
3	250 kBit
4	125 kBit
5	reserved
6	50 kBit
7	not supported
8	not supported

This service can be performed on only one LSS Slave, in configuration mode, at a time. The service must be followed by an Activate Bit Timing Parameters service. After executing this service the node may not execute any remote LSS services other than Configure Bit Timing Parameters, Activate Bit Timing Parameters and Switch Mode.

COB-ID = 7E5h

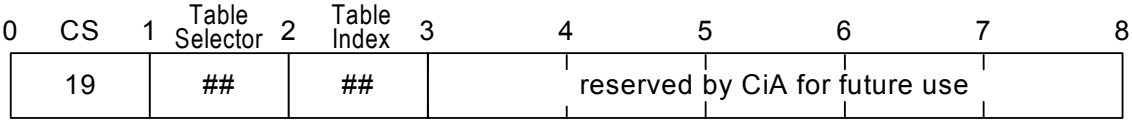


Figure 3-10 Select Bit Timing

A remote message confirms the success or failure of the service. In case of a failure, the reason is given.

COB-ID = 7E4h

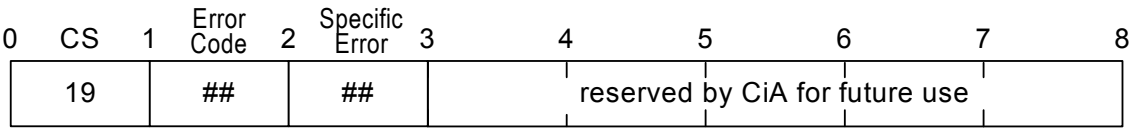


Figure 3-11 Bit Timing Confirmation Message

Error Codes:

0: protocol successfully completed
1: Node-ID out of range
2...254: reserved for further use by CiA
255: implementation specific error occured.

Specific Error Codes:

If error_code is 0 … 254, then a specific_error_code will be 0.
If error_code is 255, then a specific_error_code will be:
2: incorrect mode

3: out of range

3.3.3 Activate Bit Timing Parameters

The LSS Master's Activate Bit Timing Parameters service activates the bit timing as defined by the Configure Bit Timing Parameters service.

The switch_delay parameter specifies the length of two delay periods of equal length, which are necessary to avoid operating the bus with differing bit timing parameters. Each node performs the actual switch of the bit timing parameters switch_delay milliseconds after the reception of the command. After performing the switch, a node does not transmit any messages before the second time ´switch_delay´ has passed. This service can be performed on all LSS Slaves in 'Configuration Mode'.

COB-ID = 7E5h

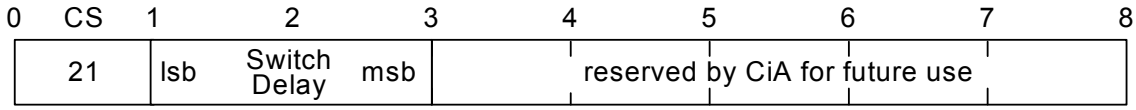


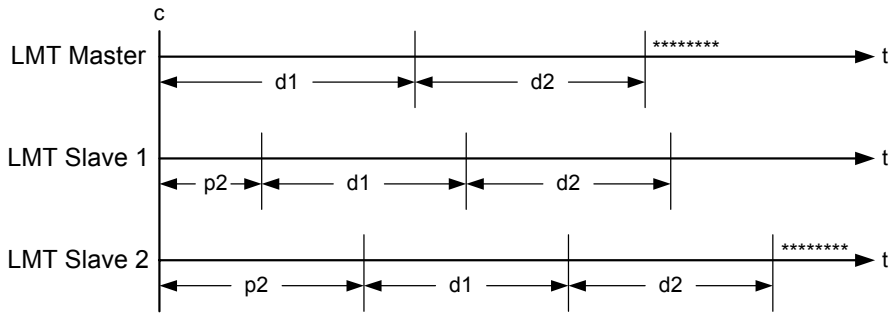
Figure 3-12 Activate Bit Timing Parameters

switch_delay:

The duration of the two periods of time to wait until the bit timing parameters switch is performed (first period). This is the length of time before any CAN message can be transmitted with the new bit timing parameters.

Note:

Nodes may have different processing times for performing the Activate Bit Timing Parameters command. Messages that are transmitted before this command may still be in the receive queue of a node. This means that a node may still transmit CAN messages with the old bit timing due to processing delay. Therefore switch_delay must be longer than the longest processing time of any node in the network. After the switch_delay time has passed, every node must perform the switch during the second switch_delay. Only after the second switch_delay has passed are all nodes guaranteed to be listening with the new bit timing parameters. Figure 3-13 shows the durations of the two switch_delays.



c: initiation of command
p1, p2: individual processing delay
d1: duration of first switch_delay period
d2: duration of second switch_delay period
********: node may be transmitting

Figure 3-13 Switch_Delay Periods

3.3.4 Store Configuration Parameters

The Store Configured Parameters service is used to store the configured parameters in non-volatile memory.

COB-ID = 7E5h

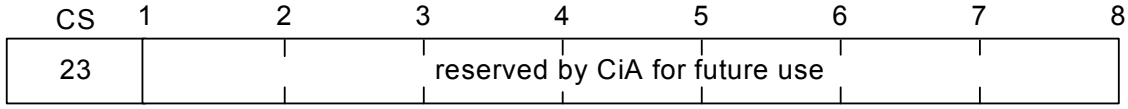


Figure 3-14 Store Configuration Parameters

A return message confirms the success or failure of the service. The reason is specified if the effort fails. This service is available for only one LSS Slave in 'Configuration Mode' at a time.

COB-ID = 7E4h

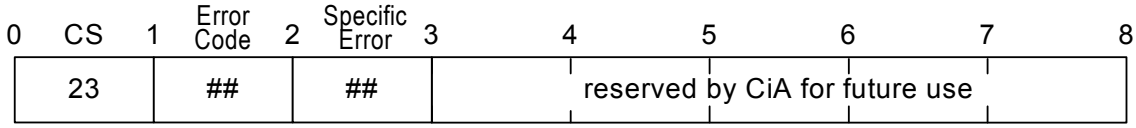


Figure 3-15 Confirm Configuration Parameters

Error Codes:

0: protocol successfully completed
1: store configuration is not supported
2: storage media access error
3 ... 254: reserved for further use by CiA
255: implementation specific error occurred.

Specific Error Codes:
If error_code is 0 … 254, then a specific_error_code will be 0.

If error_code is 255, then a specific_error_code will be:

2: incorrect mode
no other options at this time

3.4 Inquiry Services

The inquiry services are available only in configuration mode.

3.4.1 Inquire LSS Address

This service finds the LSS-address of a Slave in configuration mode. Since the LSS address has four parts (Vendor-ID, Product-Code, Revision-Number and Serial-Number), four inquiries are required.

Only one LSS slave may be in configuration mode when this service is executed. A return message contains the LSS sub-address of the Slave in configuration mode, or returns an error message.

Inquire Vendor-ID Protocol

COB-ID = 7E5h

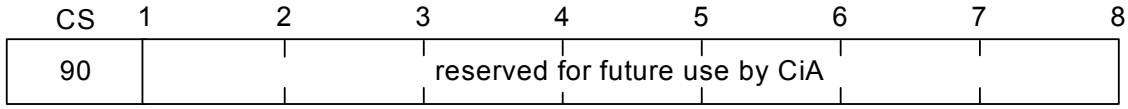


Figure 3-16 Inquire Vendor-ID

COB-ID = 7E4h

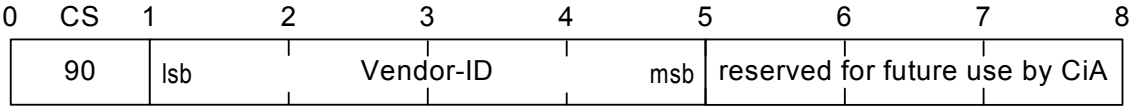


Figure 3-17 Confirm Vendor-ID

Inquire Product-Code Protocol

COB-ID = 7E5h

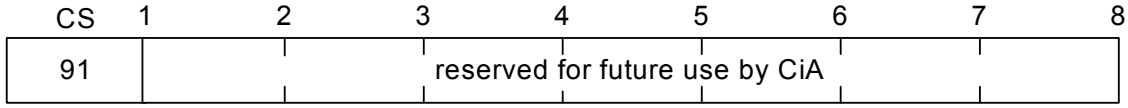


Figure 3-18 Inquire Product Code

COB-ID = 7E4h

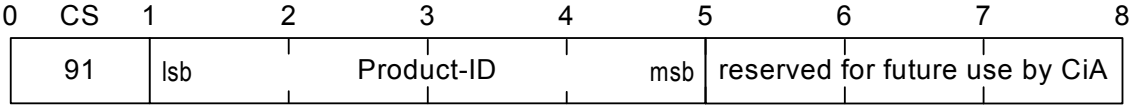


Figure 3-19 Confirm Product Code

Inquire Revision-Number Protocol

COB-ID = 7E5h

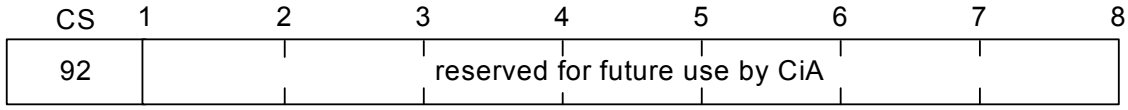


Figure 3-20 Inquire Revision-Number

COB-ID = 7E4h

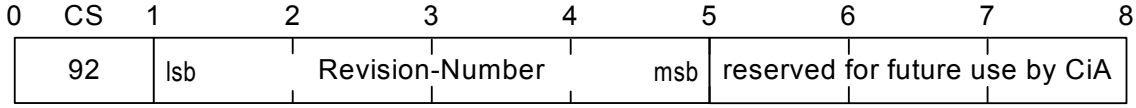


Figure 3-21 Confirm Revision-Number

Inquire Serial-Number Protocol

COB-ID = 7E5h

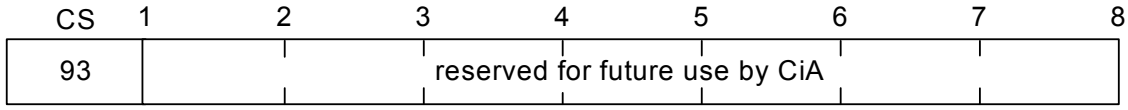


Figure 3-22 Inquire Serial-Number

COB-ID = 7E4h

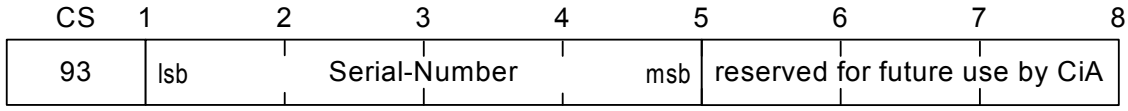


Figure 3-23 Confirm Serial -Number

3.4.2 Inquire Node-ID

This command is used to determine the Node-ID of a LSS Slave in configuration mode.

Only one LSS slave may be in configuration mode when this command is executed. The return message is the Node-ID of the LSS Slave.

Inquire Node-ID Protocol

COB-ID = 7E5h

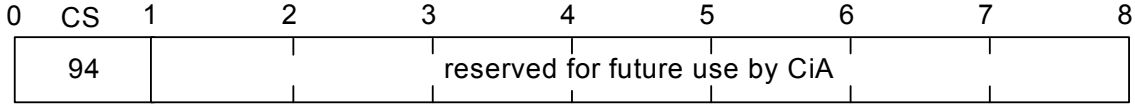


Figure 3-24 Inquire Node-ID

COB-ID = 7E4h

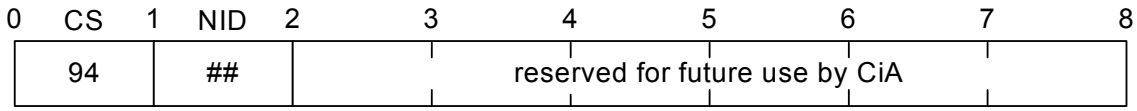


Figure 3-25 Confirm Node-ID

If the Node-ID was recently changed with a Configure Node-ID command, the original Node-ID will continue to be returned until the next power on reset. A value of FFh is returned if the Node-ID is not configured … this is only possible if the slave is in 'LSS Init State'.

3.5 Identification Services

This protocol is used to implement the 'LSS Identify Remote Slaves' service.

3.5.1 LSS Identify Remote Slaves

By means of this service, the LSS Master requests all LSS slaves, whose LSS address meets the LSS_Address_sel to identify themselves by means of the 'LSS Identify Slave' service.

LSS_Address_sel consists of a fixed Vendor ID and Product Code and a span of revision and serial numbers. This service goes unconfirmed.

Inquire Node-ID Protocol

COB-ID = 7E5h

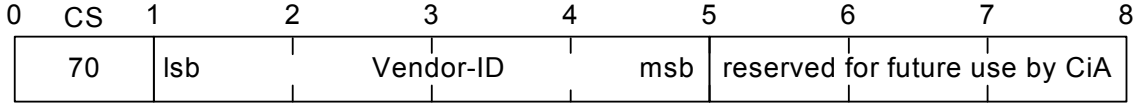


Figure 3-26 Slave Vendor-ID Inquiry

COB-ID = 7E5h

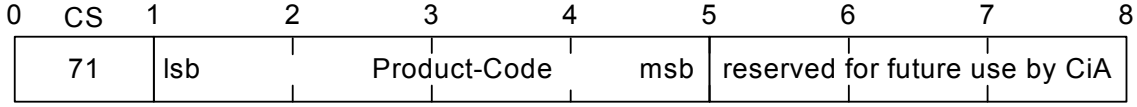


Figure 3-27 Slave Product-ID Inquiry

COB-ID = 7E5h

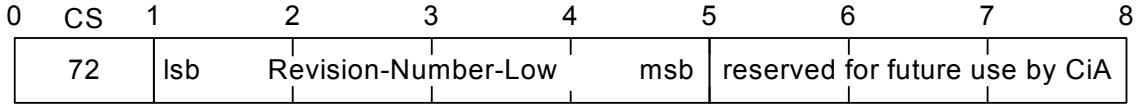


Figure 3-28 Slave Revision Number Inquiry

Revision-Number-Low:
The lower boundary of the requested revision numbers range. The Minor range must be set to 0000h.

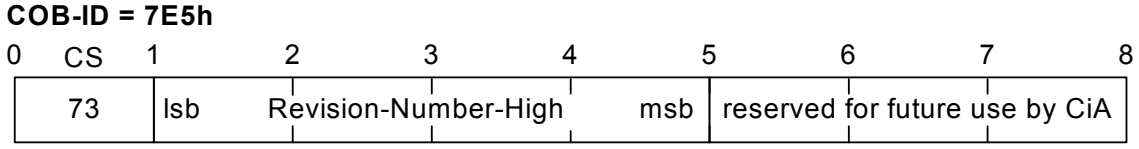


Figure 3-29 Slave Revision Number Inquiry

Revision-Number-High:

The higher boundary of the requested revision numbers range. The Minor range must be set to FFFFh.

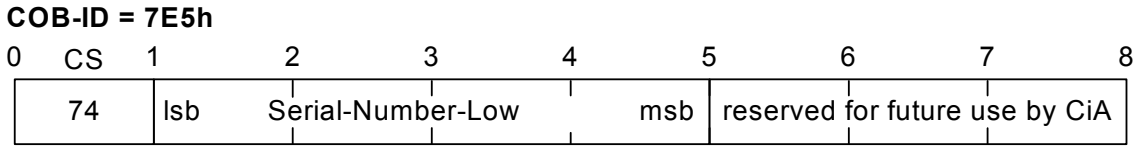


Figure 3-30 Slave Serial-Number Inquiry

Serial-Number-Low:

The lower boundary of the requested serial numbers range

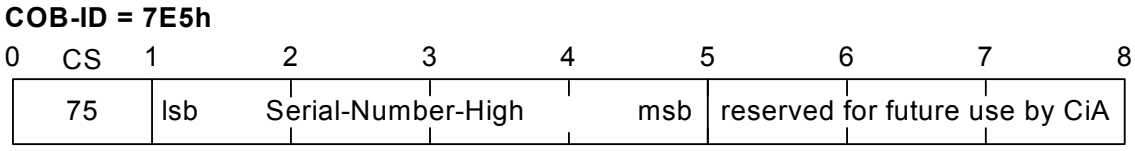


Figure 3-31 Slave Serial-Number Inquiry

Serial-Number-High:

The higher boundary of the requested serial numbers range

The boundaries are included in the interval. All LSS Slaves with matching Vendor-ID and Product-Code whose major Revision-Number and Sserial-Numbers lie within the given ranges, are requested to identify themselves with the LSS Identify Slave service.

3.5.2 LSS Identify Slave Protocol

By means of this command, an LSS Slave indicates that it is a Slave with an LSS address. This address is within the LSS_Address_sel of an 'LSS Identify Remote Slave' service (CS: 70 to 75) that was executed prior to this command. The result is unconfirmed.

Note:

If all six Identification messages are valid for an Elmo drive, the drive responds with a CS 79 message.

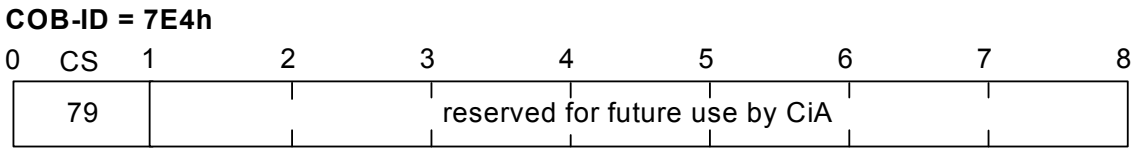


Figure 3-32 Slave Serial-Number Confirmation

3.5.3 Example

If the Master knows that there are several nodes of the same LSS type that only differ in their serial number, it can ask the following questions to locate them:

Are there any devices with serial numbers between 1276h and 2468h?

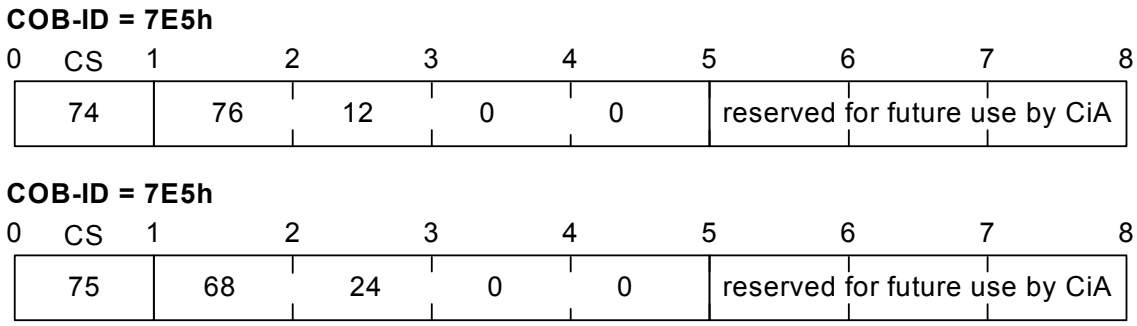


Figure 3-33 Inquire About Slaves with Serial Numbers between 1276h and 2468h?

All Slaves with Serial-Number between 1276h and 2468h send confirmation:

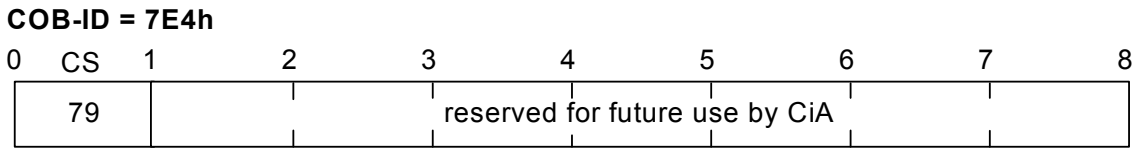


Figure 3-34 Confirmation from Slaves with Serial-Numbers between 1276h and 2468h

4 Implementation Rules

When implementing the LSS protocols, the following rules must be followed to guarantee interoperability:

CAL Layer Management (LMT)

To distinguish between LMT and LSS, all LSS services must use command specifiers in the 040h – 07fh range.

Invalid COB's

A COB is invalid if it has a COB-ID that is used by the LSS Protocol, but contains invalid parameter values according to the LSS Protocol. This can be caused by errors in the data link layer or implementation errors. Invalid COB's must be handled locally in an implementation specific way. As far as the LSS Protocol is concerned, an invalid COB must be ignored.

Time-Outs

Since COBs may be ignored, the response of a confirmed LSS service may never arrive. To resolve this situation, an implementation may, after a certain amount of time, indicate this to the service user (time-out). A time-out is not a confirm of the LSS service. A time-out indicates that the service has not completed yet. The application must deal with this situation. Time-out values are considered to be implementation specific so it is recommended that the implementation provide facilities to adjust these time-out values to the requirements of the application.